

A satellite view of Earth from space, showing a vast expanse of blue oceans and green landmasses. Several white, curved lines representing orbital paths arc across the upper portion of the image. The background transitions from a light blue at the top to a dark blue at the bottom.

Robotic Solutions For On-Orbit Servicing

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Space Missions

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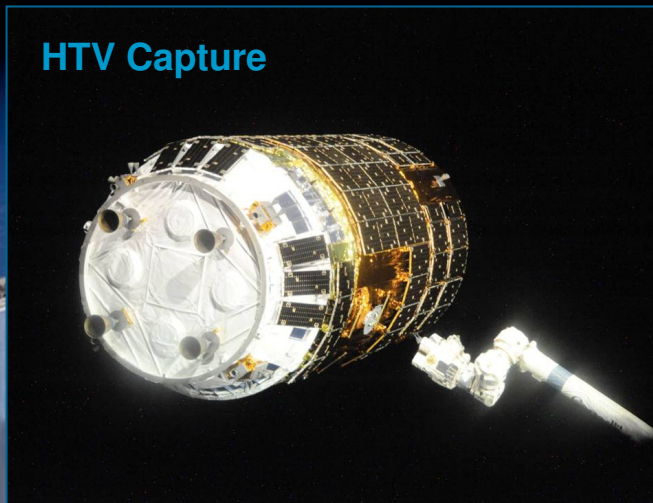
Technological and Operational Foundation for On-Orbit Servicing

86 Shuttle Missions with Robotic Operations

9 years of ISS robotic assembly and support operations

Shuttle and ISS experience provides foundation for the design and execution of future Servicing Missions

HTV Capture



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- **Shuttle and ISS experience provides foundation for the design and execution of future Servicing Missions**
 - Operations planning and workarounds
 - Man and machine coordination
 - Robotic control from the ground
 - Command path signal delay, safety
 - Robotic performance in 0g
 - handling large structures, contact operations, vehicle capture
 - force sensing and regulation
 - design Verification strategies
 - Supportable On-Orbit Robotic Equipment
 - long life,
 - maintainable and interchangeable parts

Autonomous Servicing of Prepared Clients

DARPA Orbital Express 2007



- Key Servicing Functions Demonstrated in LEO for remote servicing missions
- Autonomous vehicle capture
- Autonomous Computer and Battery exchange
- autonomous fluid transfer
- streamlined operations approach
- candidate servicing interface standard

Demonstrated Strategies for Clients designed to Non-Robotic Standards

- GSFC and MDA demonstration of dexterous robotics with HST HiFi mockup in 2004-2005
- Planned robotic compatibility can be non-invasive to a client

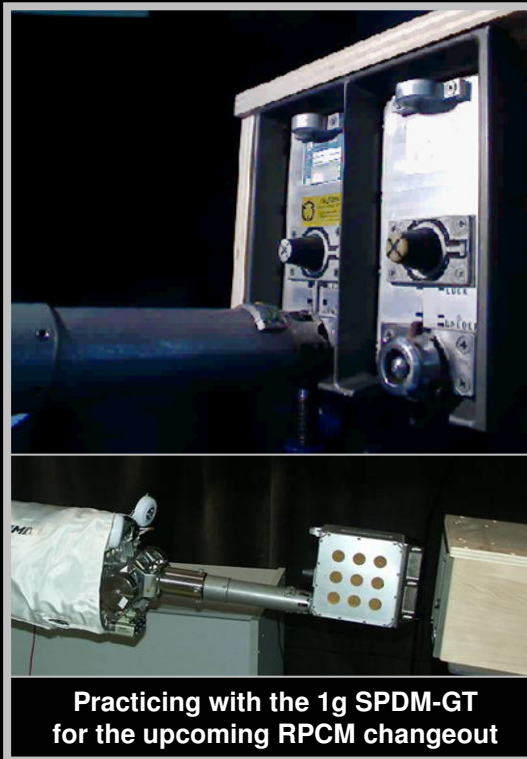
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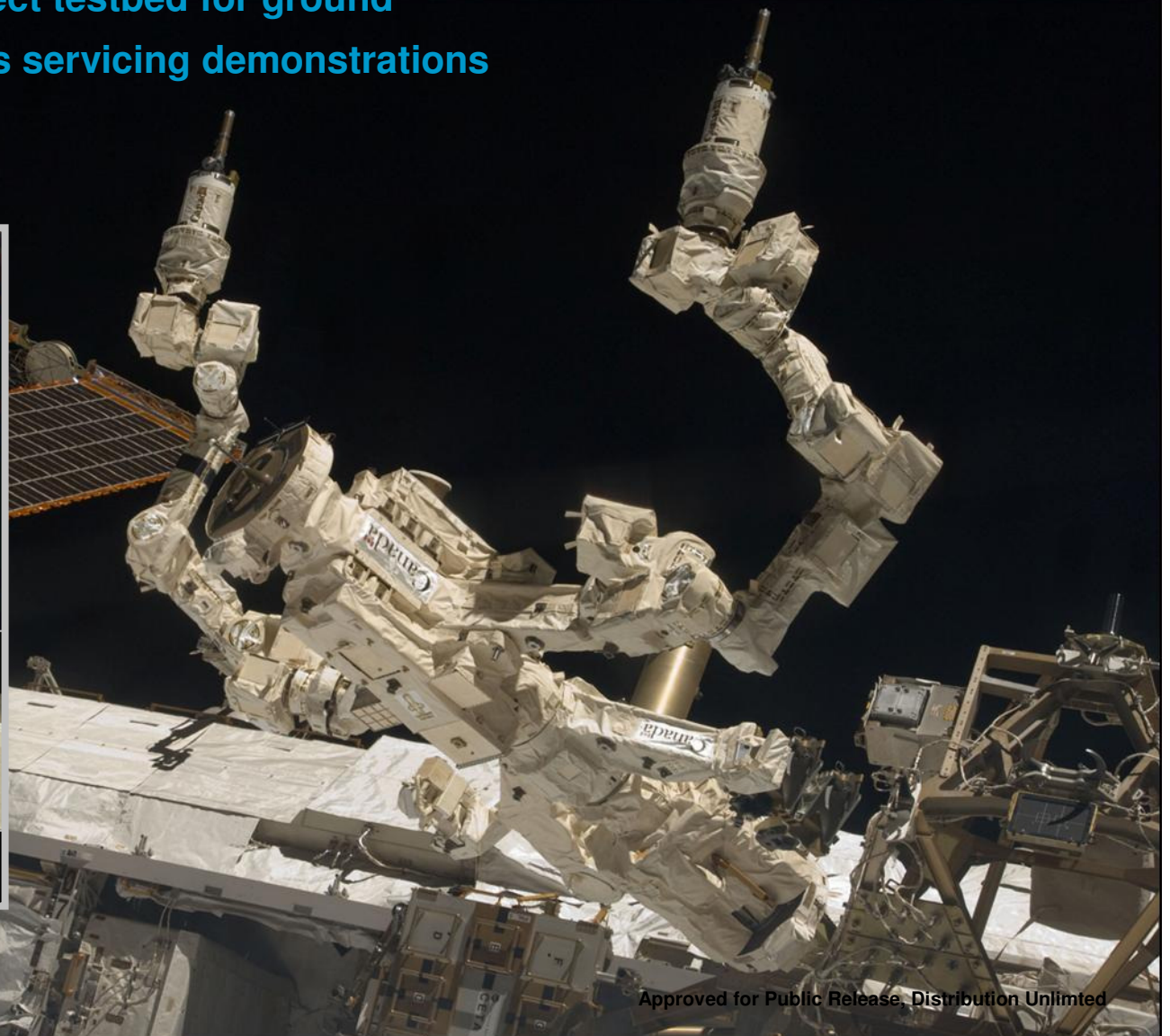
- **GSFC and MDA demonstration of dexterous robotics with HST HiFi mockup in 2004-2005**
 - Tools for non-traditional robotic tasks
 - Latches, J-hooks, ground straps, electrical connectors, large instruments, cables
 - supervised autonomy
 - Combination of automatic modes and tele-operational modes
 - Model based planning with real time correction
 - situational awareness, worksite registration strategies, and local force control to handle planning model errors for trajectories and contact operations
 - Up to 7 seconds of command path latency accommodated
- Demonstrated that robotic servicing can be applied to a client that is designed to any standard and therefore...
- **Planned robotic compatibility can be non-invasive to a client**

On-orbit Test bed for Advanced Servicing Missions

Dextre on ISS – perfect testbed for ground controlled, dexterous servicing demonstrations

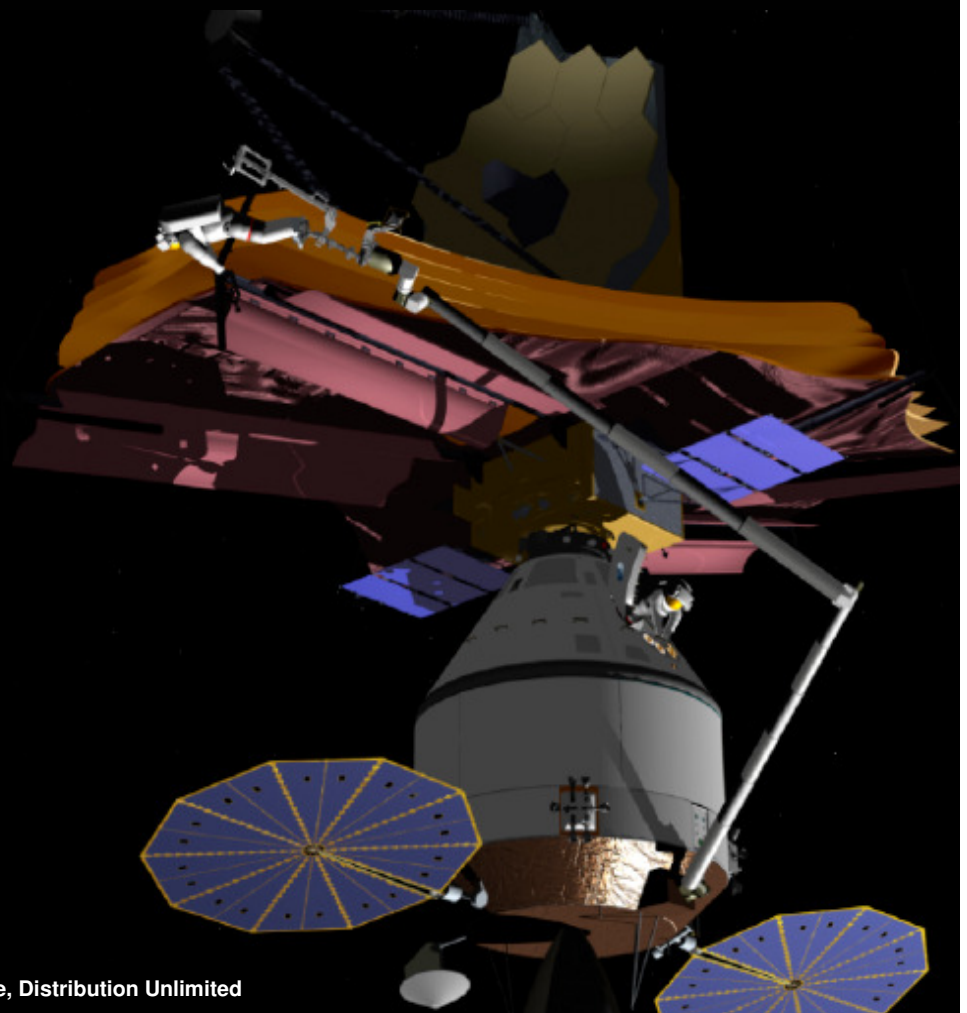


Practicing with the 1g SPDM-GT for the upcoming RPCM changeout



Next Generation Servicing Technologies

- Exploration Missions beyond GEO
- Mass, cost, operational optimization



- **Exploration Missions beyond GEO**

- CSA funded development to advance Next Generation Missions, architectures and technologies:
 - Role of robotic servicing
 - Assembly
 - Risk reduction
 - Outfitting
 - Life extension, enhancement
 - Mission compatibility
 - Packaging of large robots
 - Mass optimization
 - cost effectiveness
 - Operational Optimization
 - Consolidated operators console for streamlined mission planning and support

Commercial Satellite Servicing

Robotic technologies are sufficiently mature for GEO satellite servicing

A cost effective servicing mission can validate the operating principles and value of a serviceable space infrastructure

- MDA is designing a servicer that can add 50 years of life to 9-11 existing GEO satellites through the re-supply of propellants
- Able to tow clients to graveyard orbit or adjust orbit
- Combines operational and technical lessons learned from preceding robotic missions
 - robotic arm to expose client FDVs and handle propellant re-supply tools
 - Human aided rendezvous using techniques developed for remote control of robotics
 - automated docking using client apogee engine

**SIS : a Commercial On-Orbit Servicer
for Multiple Clients in GEO**